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Where f = center frequency in kHz of each of the possible 8-kHz bands.

(iii) *RMS Voltage at frequencies above 270 kHz.* The rms value of the metallic voltage components in the frequency range of 270 kHz to 6 MHz, averaged over 2 microseconds, shall not exceed -15 dBV. This limitation applies with a metallic termination having an impedance of 135 ohms.

(iv) *Peak Voltage.* The total peak voltage for all frequency components in the 4 kHz to 6 MHz band shall not exceed 4.0 volts.

(3) *Longitudinal voltage.* Frequencies below 4kHz: The weighted rms voltage in the frequency band from 10 Hz to 4kHz, averaged over 100 milliseconds is the resultant of all the component longitudinal voltages in the band after weighing according to the transfer function of $f/4000$, where f is the frequency in Hz, shall not exceed the maximum indicated below under the conditions stated in para. (g) of this section.

(i) *Frequencies below 4kHz.* The weighted rms voltage in the frequency band from 10 Hz to 4kHz, averaged over 100 milliseconds is the resultant of all the component longitudinal voltages in the band after weighing according to the transfer function of $f/4000$, where f is the frequency in Hz, shall not exceed the maximum indicated below under the conditions stated in § 8.308(g).

| Frequency range | Maximum RMS voltage |
|-----------------|---------------------|
| 10 Hz - 4 kHz | -37 dBV |

(ii) 4 kHz to 270 kHz

| Center Frequency (f) of 8-kHz Band | Maximum Voltage in all 8-kHz Bands | Longitudinal Terminating Impedance |
|--|------------------------------------|------------------------------------|
| 8 kHz to 12 kHz | $(18.4 + 20 \log f)$ dBV | 500 Ohms |
| 12 kHz to 42 kHz | $(3 - 40 \log f)$ dBV | 90 Ohms |
| 42 kHz to 266 kHz | -62 dBV | 90 Ohms |

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Where f = center frequency in kHz of each of the possible 8-kHz bands.

(iii) *270 kHz to 6 MHz.* The rms value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHz shall, averaged over 2 microseconds, not exceed -30 dBV. This limitation applies with a longitudinal termination having an impedance of 90 ohms.

(d) *Longitudinal voltage at frequencies below 4 kHz.* The weighted rms voltage* averaged over 100 milliseconds that is resultant of all of the component longitudinal voltages in the 100 Hz to 4 kHz band after weighting according to the transfer function of $f/4000$ where f is the frequency in Hertz, shall not exceed the maximum indicated under the conditions stated in § 68.308(g).

| Frequency range | Maximum Weighted rms Voltage | Impedance |
|-----------------|------------------------------|-----------|
| 100 Hz to 4 kHz | - 30 dBV | 500 ohms |

* NOTE: Average magnitudes may be used for signals that have peak-to-rms ratios of 20 dB and less. The rms limitations must be used instead of average values if the peak-to rms ratio of the interfering signal exceeds this value.

(e) *Voltage in the 4 kHz to 6 MHz frequency range-general case - 2-wire and 4-wire lossless interface (except LADC).* Except as noted, rms voltage as averaged over 100 milliseconds at the telephone connections of registered terminal equipment and registered protective circuitry in all of the possible 8 kHz bands within the indicated frequency range and under the conditions specified in subsection (g) shall not exceed the maximum indicated below. For (1)(I) and (2)(I) below, " f " is the center frequency in kHz of each of the possible 8-kHz bands beginning at 8 kHz.

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(1) *Metallic Voltage. 4 kHz to 270 kHz:*

| Center Frequency (f) of 8 kHz Band | Max Voltage in all 8 kHz bands | Metallic Terminating Impedance |
|------------------------------------|--------------------------------|--------------------------------|
| 8 kHz to 12 kHz | $-(6.4 + 12.6 \log f)$ dBV | 300 ohms |
| 12 kHz to 90 kHz | $(23 - 40 \log f)$ dBV | 135 ohms |
| 90 kHz to 266 kHz | -55 dBV | 135 ohms |

(2) *Longitudinal voltage*

(i) *4 kHz to 270 kHz.*

(ii) *270 kHz to 6 MHz.* The rms value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHz, shall not exceed -30 dBV. This limitation applies with a longitudinal termination having an impedance of 90 ohms.

| Center Frequency (f) of 8kHz band | Max Voltage in all 8 kHz bands | Longitudinal Terminating Impedance |
|-----------------------------------|--------------------------------|------------------------------------|
| 8 kHz to 12 kHz | $-(18.4 + 20 \log f)$ dBV | 500 ohms |
| 12 kHz to 42 kHz | $(2 - 40 \log f)$ dBV | 90 ohms |
| 42 kHz to 266 kHz | -62 dBV | 90 ohms |

(f) *LADC interface.* The metallic voltage shall comply with the general requirements in (1) below as well as the additional requirements specified in (2) and (3) as stated. The requirements apply under the conditions specified in § 68.308(g). Terminal equipment for which the magnitude of the source and/or terminating impedance exceeds 300 Ohms, at any frequency in the range of 100 kHz to 6 MHz, at which the signal (transmitted and/or received) has significant power, shall be deemed not to comply with these requirements. A signal is considered to have 'significant power' at a given frequency if that frequency is contained in a designated set of

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frequency bands that collectively have the property that the rms voltage of the signal components in those bands is at least 90% of the rms voltage of the total signal. The designated set of frequency bands must be used in testing all frequencies.

(1) *Metallic voltages - frequencies below 4 kHz.*

(i) *Weighted rms voltage in the 10 Hz to 4 kHz frequency band.* The weighted rms metallic voltage in the frequency band from 10 Hz to 4 kHz, averaged over 100 milliseconds that is the resultant of all the component metallic voltages in the band after weighting according to the transfer function of $f/4000$ where f is the frequency in Hertz, shall not exceed the maximum indicated below under the conditions stated in section (g).

| Frequency range | Maximum voltage |
|-----------------|-----------------|
| 10 Hz to 4 kHz | +3 dBV |

(ii) *RMS Voltage in 100 Hz bands in the frequency range 0.7 kHz to 4 kHz.* The rms metallic voltage averaged over 100 milliseconds in the 100-Hz bands having center frequencies between 750 Hz and 3950 Hz shall not exceed the maximum indicated below.

| Center frequency (f) of 100-Hz bands | Maximum voltage |
|--------------------------------------|-----------------|
| 750 to 3950 Hz | -6 dBV |

(2) *Metallic Voltages - frequencies above 4 kHz - LADC interface.*

(I) *100-Hz bands over frequency range of 4 kHz to 270 kHz.* The rms voltage as averaged over 100 milliseconds in all possible 100-Hz bands between 4 kHz and 270 kHz for the indicated range of center frequencies and under the conditions specified in § 68.308(g) shall not exceed the maximum indicated below:

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| Center frequency (f) of 100-Hz bands | Maximum voltage in all 100-Hz bands |
|--------------------------------------|-------------------------------------|
| 4.05 kHz to 4.60 kHz | 0.5 dBV |
| 4.60 kHz to 5.45 kHz | $(59.2 - 90 \log f)$ dBV |
| 5.45 kHz to 59.12 kHz | $(7.6 - 20 \log f)$ dBV |
| 59.12 kHz to 266.00 kHz | $(43.1 - 40 \log f)$ dBV |

Where f = center frequency in kHz of each of the possible 100 Hz bands.

(ii) *8-kHz bands over frequency range of 4 kHz to 270 kHz.* The rms voltage as averaged over 100 milliseconds in all of the possible 8-kHz bands between 4 kHz and 270 kHz for the indicated range of center frequencies and under the conditions specified in § 68.308(g) shall not exceed the maximum indicated below:

| Center frequency (f) of 8-kHz bands | Maximum voltage in all 8-kHz bands |
|-------------------------------------|------------------------------------|
| 8 kHz to 120 kHz | $(17.6 - 20 \log f)$ dBV |
| 120 kHz to 266 kHz | $(59.2 - 40 \log f)$ dBV |

Where f = center frequency in kHz of each of the possible 8-kHz bands.

(iii) *RMS Voltage at frequencies above 270 kHz.* The rms value of the metallic voltage components in the frequency range of 270 kHz to 6 MHz, averaged over 2 microseconds, shall not exceed -15 dBV. This limitation applies with a metallic termination having an impedance of 135 ohms.

(iv) *Peak Voltage.* The total peak voltage for all frequency components in the 4

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kHz to 6 MHz band shall not exceed 4.0 volts.

(3) *Longitudinal voltage*

(i) *Frequencies below 4kHz.* The weighted rms voltage in the frequency band from 10 Hz to 4kHz, averaged over 100 milliseconds is the resultant of all the component longitudinal voltages in the band after weighing according to the transfer function of $f/4000$, where f is the frequency in Hz, shall not exceed the maximum indicated below under the conditions stated in § 8.308(g).

| Frequency range | Maximum RMS voltage |
|-----------------|---------------------|
| 10 Hz - 4 kHz | 37 dBV |

(ii) 4 kHz to 270 kHz

| Center Frequency (f) of 8-kHz Band | Maximum Voltage in all 8-kHz Bands | Longitudinal Terminating Impedance |
|---------------------------------------|---------------------------------------|--|
| 8 kHz to 12 kHz | $-(18.4 + 20 \log f)$ dBV | 500 Ohms |
| 12 kHz to 42 kHz | $(3 - 40 \log f)$ dBV | 90 Ohms |
| 42 kHz to 266 kHz | -62 dBV | 90 Ohms |

Where f = center frequency in kHz of each of the possible 8-kHz bands.

(iii) *270 kHz to 6 MHz.* The rms value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHz shall, averaged over 2 microseconds, not exceed -30 dBV. This limitation applies with a longitudinal termination having an impedance of 90 ohms.

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Figure 68.308(a)

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(g) *Requirements in paragraphs (d), (e) and (f) apply under the following conditions:*

(1) All registered terminal equipment, except equipment to be used on LADC, and all registered protective circuitry must comply with the limitations when connected to a termination equivalent to the circuit depicted in Figure 68.308(a) and when placed in all operating states of the equipment except during network control signaling. LADC registered terminal equipment must comply with the metallic voltage limitations when connected to circuits of § 68.3(i) and must comply with the longitudinal limitations when connected to circuits of Figure 68.308(a), as indicated.

(2) All registered terminal equipment and registered protective circuitry must comply with the limitations in the off-hook state over the range of loop currents that would flow with the equipment *connected* to an appropriate simulator circuit.

(3) Registered terminal equipment and registered protective circuitry with provision for through-transmission from other equipments shall comply with the limitations with a 1000 Hz tone applied from a 600-ohm source (or, if appropriate a source which reflects a 600-ohm impedance across tip and ring) at the maximum level that would be applied during normal operation. Registered protective circuitry for data shall also comply with the tone level 10 dB higher than the overload point.

(4) For registered terminal equipment or registered protective circuitry with non-registered signal source input, such as music on hold, the out of band signal power requirements shall be met using an input signal with a frequency range of 200 Hz to 20 kHz and the level set at the overload point.

(5) Except during the transmission of ringing (§ 68.306(d)) and Dual Tone Multi-frequency (DTMF) signals, LADC registered terminal equipment shall comply with all requirements in all operating states and with loop current that may be drawn for such purposes as loop back signaling. The requirements in para. (f) (1) of this section except in paragraphs (i) and (ii) also apply during the application of ringing. The requirement in para. (d) and the requirements in para. f)(1)(i) and (1)(ii) of this section apply during ringing for frequencies above 300 Hz and with the maximum voltage limits raised by 10 dB. DTMF signals which are used for the transmission of alphanumeric information and which comply with the requirements in para. (f)(1)(i) and in para. (f)(2) or (3) as applicable, shall be deemed to comply with the requirements in para. (f)(1)(ii) provided that, for automatically originated DTMF signals, the duty cycle is less than 50 percent.

(6) LADC registered terminal equipment shall comply with all applicable requirements, except those specified in paras (f)(1)(i) and (ii) of this section, during the

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transmission of each possible data signal sequence of any length. For compliance with para. (f)(3)(i) of this section, the limitation applies to the rms voltage averaged as follows:

(i) For digital signals, baseband or modulated on a carrier, for which there are defined signal element intervals, the rms voltage is averaged over each such interval. Where multiple carriers are involved, the voltage is the power sum of the rms voltages for the signal element intervals for each carrier.

(ii) For baseband analog signals, the rms voltage is averaged over each period (cycle) of the highest frequency of the signal (3 dB point on the spectrum). For analog signals that are modulated on a carrier (whether or not the carrier is suppressed), it is averaged over each period (cycle) of the carrier. Where multiple carriers are involved, the voltage is the power sum of the rms voltage for each carrier.

(iii) For signals other than the types defined in paras. (g)(6)(I) and (ii) of this section, the peak amplitude of the signal must not exceed +1 dBV.

(7) Equipment shall comply with the requirements in paras. (f)(1)(i) and (ii) of this section, during any data sequence that may be transmitted during normal use with a probability greater than 0.001. If the sequences transmitted by the equipment are application dependent, the user instruction material shall include a statement of any limitations assumed in demonstrating compliance of the equipment.

(8) In addition to the conditions specified in para. (5) of this section, LADC registered terminal equipment which operates in one or more modes as a receiver, shall comply with requirements in para. (f)(3) of this section with a tone at all frequencies in the range of potential received signals and at the maximum power which may be received.

(h) *Interference limitations for transmission of bipolar signals over digital services.*

(1) *Limitations on Terminal Equipment Connection to Subrate Digital Services.*

(i) *Pulse repetition rate.* The pulse repetition rate shall be synchronous with 2.4, 3.2, 4.8, 6.4, 9.6, 12.8, 19.2, 25.6, 38.4, 56.0, or 72 kbps per second.

(ii) *Template for maximum output pulse.* When applied to a 135 Ohm resistor, the instantaneous amplitude of the largest isolated output pulse obtainable from the registered terminal equipment shall not exceed by more than 10% the instantaneous voltage defined by a template obtained as follows: The limiting pulse template shall be

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determined by passing an ideal 50% duty cycle rectangular pulse with the amplitude/pulse rate characteristics defined in Table 68.308(c) through a single real pole low pass filter having a cutoff frequency in Hertz equal to 1.3 times the bit rate. For bit rates of 2.4, 3.2, 4.8, 6.4, 9.6 and 12.8 kbps, the filtered pulses shall also be passed through a filter providing the additional attenuation in Table 68.308 (d).

Table 68.308(c) - Driving Pulse Amplitude

| Line Rate (kbps) | User Data Rate (R) (kbps) | Amplitude (A) (volts) |
|---------------------|------------------------------|--------------------------|
| 2.4 | 2.4 | 1.66 |
| 3.2 | 2.4 with SC* | 1.66 |
| 4.8 | 4.8 | 1.66 |
| 6.4 | 4.8 with SC* | 1.66 |
| 9.6 | 9.6 | 0.83 |
| 12.8 | 9.6 with SC* | 0.83 |
| 19.2 | 19.2 | 1.66 |
| 25.6 | 19.2 with SC* | 1.66 |
| 38.4 | 38.4 | 1.66 |
| 51.2 | 38.4 with SC* | 1.66 |
| 56 | 56 | 1.66 |
| 72 | 56 with SC* | 1.66 |
| 72 | 64 | 1.66 |

* SC: Secondary Channel

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Table 68.308(d) - Minimum Additional Attenuation

| Line Rate (R) (kbps) | Attenuation in Frequency Band 24-32 kHz (dB) | Attenuation in Frequency Band 72-80 kHz (dB) |
|-------------------------|--|--|
| 2.4 | 5 | 1 |
| 3.2 | 5 | 1 |
| 4.8 | 13 | 9 |
| 6.4 | 13 | 9 |
| 9.6 | 17 | 8 |
| 12.8 | 17 | 8 |

The attenuation indicated may be reduced at any frequency within the band by the weighting curve of Table 68.308(e). Minimum rejection is never less than 0 dB; i.e., the weight does not justify gain over the system without added attenuation.

Table 68.308(e) Attenuation Curve

| 24-32 kHz Band | 72-80 kHz Band | Attenuation Factor dB |
|----------------------|----------------------|-----------------------------|
| 24 | 72 | -18 |
| 25 | 73 | -3 |
| 26 | 74 | -1 |
| 27 | 75 | 0 |
| 29 | 76 | 0 |
| 29 | 77 | 0 |
| 30 | 78 | -1 |
| 31 | 79 | -3 |
| 32 | 80 | -18 |

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(iii) *Average power.* The average output power when a random signal sequence, (0) or (1) equiprobable in each pulse interval, is being produced as measured across a 135 ohm resistance shall not exceed 0 dBm for 9.6 and 12.8 kbps or +6 dBm for all other rates shown in Table 68.308(b).

(iv) *Encoded analog content.* If registered terminal equipment connecting to subrate services contains an analog-to-digital converter, or generates signals directly in digital form that are intended for eventual conversion into voiceband analog signals, the encoded analog content of the digital signal must be limited. The maximum equivalent power of encoded analog signals for other than live voice as derived by a zero level decoder test configuration shall not exceed -12 dBm when averaged over any 3-second time interval. The maximum equivalent power of encoded analog signals as derived by a zero level decoder test configuration for signals intended for network control signaling shall not exceed -3 dBm when averaged over any 3-second interval.

(2) *Limitations on Terminal Equipment Connecting to 1.544 Mbps Digital Services.*

(i) *Pulse repetition rate:*

The free running line rate of the transmit signal shall be 1.544 Mbps with a tolerance of ± 32 ppm., i.e., ± 50 bps.

(ii) *Output pulse templates.* The registered terminal equipment shall be capable of optionally delivering three sizes of output pulses. The output pulse option shall be selectable at the time of installation.

(A) *Option A output pulse.* When applied to a 100 ohm resistor, the instantaneous amplitude of the largest output pulse obtainable from the registered terminal equipment shall fall within the pulse template illustrated in Figure 68.308 (b). The mask may be positioned horizontally as needed to encompass the pulse, and the amplitude of the normalized mask may be uniformly scaled to encompass the pulse. The baseline of the mask shall coincide with the pulse baseline.

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(B) *Option B output pulse.* When applied to a 100-ohm resistor, the instantaneous amplitude of the output from the registered terminal equipment obtained when Option B is implemented shall fall within the pulse template obtained by passing the bounding pulses permitted by Figure 68.308(b) through the following transfer function.

$$\frac{V_{out}}{V_{in}} = \frac{n_2 S^2 + n_1 S + n_0}{d_3 S^3 + d_2 S^2 + d_1 S + d_0}$$

where:

$$n_0 = 1.6049 \times 10^6$$

$$n_1 = 7.9861 \times 10^{-1}$$

$$n_2 = 9.2404 \times 10^{-8}$$

$$d_0 = 2.1612 \times 10^6$$

$$d_1 = 1.7223$$

$$d_2 = 4.575 \times 10^{-7}$$

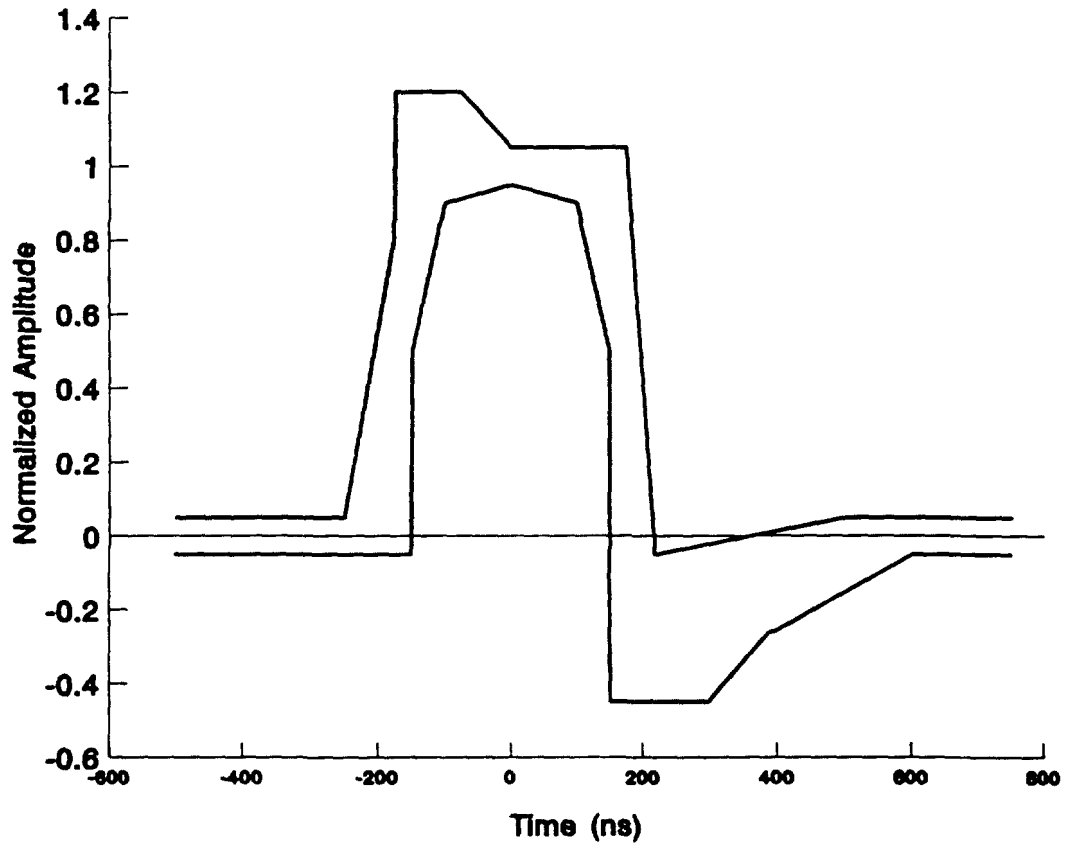
$$d_3 = 3.8307 \times 10^{-14}$$

$$S = j 2 \pi f$$

$$f = \text{frequency (Hertz)}$$

(C) *Option C output pulse.* When applied to a 100-ohm resistor, the instantaneous amplitude of the output from the registered terminal equipment obtained when Option C is implemented shall fall within the pulse template obtained by passing the pulses obtained in Option B through the transfer function in Option B a second time.

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MAXIMUM CURVE

| NANO-SECONDS | -500 | -250 | -175 | -175 | -75 | 0 | 175 | 220 | 500 | 750 | | |
|----------------------|------|------|------|------|-----|------|------|------|-----|-----|--|--|
| NORMALIZED AMPLITUDE | .05 | .05 | .8 | 1.2 | 1.2 | 1.05 | 1.05 | -.05 | .05 | .05 | | |

MINIMUM CURVE

| NANO-SECONDS | -500 | -150 | -150 | -100 | 0 | 100 | 150 | 150 | 300 | 396 | 600 | 750 |
|----------------------|------|------|------|------|-----|-----|-----|------|------|------|------|------|
| NORMALIZED AMPLITUDE | -.05 | -.05 | .5 | .9 | .95 | .9 | .5 | -.45 | -.45 | -.26 | -.05 | -.05 |

Figure 68.308(b) (Ref. EIA/TIA 547-1989)

Isolated Pulse Template and Corner Points for 1.544 Mbps equipment

NOTE: The pulse amplitude is 2.4 to 3.6 V. (Use constant scaling factor to fit normalized template.)

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(iii) *Adjustment of signal voltage.* The signal voltage at the network interface must be limited so that the range of pulse amplitudes received at the first telephone company repeater is controlled to ± 4 dB. This limitation is achieved by implementing the appropriate output pulse option as a function of telephone company cable loss as specified at time of installation.

| Cable Loss at 772 kHz (dB) | Terminal Equipment | |
|-------------------------------|--------------------|--------------------|
| | Output Pulse | Loss at 772 kHz |
| 15 to 22 | Option A | 0 |
| 7.5 to 15 | Option B | 7.5 |
| 0 to 7.5 | Option C | 15 |

(iv) *Output power.* The output power in a 3 kHz band about 772 kHz when an all ones signal sequence is being produced as measured across a 100 ohm terminating resistance shall not exceed +19 dBm. The power in a 3 kHz band about 1.544 MHz shall be at least 25 dB below that in a 3 kHz band about 772 kHz.

(v) *Encoded Analog Content.* If registered terminal equipment connected to 1.544 Mbps digital service contains an analog-to-digital converter, or generates signals directly in digital form that are intended for eventual conversion into voiceband analog signals, the encoded analog content of the subrate channels within the 1.544 Mbps signal must be limited. The maximum equivalent power of encoded analog signals for other than live voice that are not intended for network control signaling as derived by a zero level decoder test configuration shall not exceed -12 dBm when averaged over any 3-second time interval. The maximum equivalent power of encoded analog signals as derived by a zero level decoder test configuration for signals intended for network control signaling shall not exceed -3 dBm when averaged over any 3-second interval.

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9. Section 68.310 is revised to read as follows:

§ 68.310 Transverse balance limitations.

(a) *Technical Description and Application.* The Transverse Balance_{m-1} coefficient is expressed as

$$BALANCE_{m-1} = 20 \log_{10} \frac{e_M}{e_L}$$

Where e_L is the longitudinal voltage produced across a longitudinal termination Z_0 and e_M is the metallic voltage across the tip-ring or tip 1 and ring 1 interface of the input port when a voltage (at any frequency between f_1 and $< f_2$, see Table 68.310(a) is applied from a balanced source with a metallic impedance Z_0 (see Table 68.310(a). The source voltage should be set such that $e_M = E$ volts (see Table 68.310(a) when a termination of Z_0 is substituted for the terminal equipment

The minimum transverse balance coefficient specified in this section (as appropriate) shall be equalled or exceeded for all 2-wire network ports, OPS line ports and the transmit pair (tip and ring) and receive pair (tip 1 and ring 1) of all 4-wire network ports at all values of dc loop current that the port under test is capable of drawing when attached to the appropriate loop simulator circuit (See 68.3). An illustrative test circuit that satisfies the above conditions is shown in Figure 68.310-1(a) for analog and 68.310-1(b) for digital and substrate; other means may be used to determine the transverse balance coefficient specified herein, provided that adequate documentation of the appropriateness, precision, and accuracy of the alternative means is provided by the applicant.

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The minimum transverse balance requirements specified below shall be equalled or exceeded under all reasonable conditions of the application of earth ground to the equipment or protective circuitry under test.

Table 68.310(a)

| | Analog Voiceband | Subrate Digital | 1.544 Mbps Digital |
|--------------------------------------|---------------------|--------------------|-----------------------|
| Longitudinal Termination - Z_L | 500 ohms | See Table 310(b) | 90 ohms |
| Metallic Source Impedance - Z_0 | 600 ohms | 135 ohms | 100 ohms |
| Lower Frequency - f_1 | 200 Hz | 200 Hz | 10 kHz |
| Upper Frequency - f_2 | 4 kHz | * | 1.544 MHz |
| Metallic Voltage for Test - E | 0.775 V | 0.367 V | 0.316 V |

* The upper frequency equals the digital line rate for the subrate service under test (See Table 68.310(b)).

(b) *Analog Voiceband Equipment.* All registered analog voiceband equipment shall be tested in the off-hook state. The minimum transverse balance requirement in the off-hook state shall be 40 dB, throughout the range of frequencies specified in Table 68.310(a). For some categories of equipment, additional requirements also apply to the on-hook state. When both off-hook and on-hook requirements apply, they are:

| State | Frequency (f) | Balance |
|----------|----------------------------|---------|
| Off-hook | 200 Hz : f \leq 4000 Hz | : 40 dB |
| On-hook | 200 Hz : f \leq 1000 Hz | : 60 dB |
| On-hook | 1000 Hz : f \leq 4000 Hz | : 40 dB |

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(1) For analog one-port 2-wire terminal equipment with loop-start, ringdown, or inband signaling or for voiceband metallic channel applications, both off-hook and on-hook requirements apply.

(2) For analog one port equipment with ground-start and reverse-battery signaling only off-hook requirements apply.

(3) For analog registered protective circuitry for 2-wire applications with loop-start, ringdown, or inband signaling; or for voiceband metallic channel applications, both off-hook and on-hook requirements apply.

Criteria shall be met with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated in an impedance that will be reflected to the telephone connection as 600 Ohms in the off-hook state of the registered protective circuit, and the interface should not be terminated in the on-hook state. Figure 68.310(b) shows the interface of the protective circuitry being tested and the required arrangement at the interface to other equipment.

(4) For analog registered protective circuitry with ground-start and reverse-battery signaling only off-hook requirements apply. Criteria shall be met with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated in an impedance that will be reflected to the telephone connection as 600 ohms in the off-hook state of the registered protective circuit. Figure 68.310(b) shows the interface of the protective circuitry under test and the required arrangement at the interface to the other equipment.

(5) For analog multi-port equipment with loop-start signaling both off-hook and on-hook requirements apply. Criteria shall be satisfied for all ports when all the ports not under test are terminated in their appropriate networks, as will be identified below, and when interface connections other than the ports are terminated in circuits appropriate to that interface. The minimum transverse balance coefficients shall also be satisfied for all values of dc loop current that the registered equipment is capable of drawing through each of its ports when these ports are attached to the loop simulator circuit specified in these rules. The termination for all ports other than the particular one whose transverse balance coefficient is being measured shall have a metallic impedance of 600 ohms.

(6) For analog multi-port equipment with ground-start and reverse-battery signaling, only off-hook requirements apply. Criteria shall be satisfied for all ports when all ports not under test are terminated in their appropriate networks as will be identified

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below, and when interface connections other than the ports are terminated in circuits appropriate to that interface. The minimum transverse balance coefficients shall be satisfied for all values of dc loop current that the registered equipment is capable of drawing through each of its ports when these ports are attached to the loop simulator circuit specified in these rules. The terminations for all ports other than the particular one whose transverse balance coefficient is being measured shall have a metallic impedance of 600 ohms and a longitudinal impedance of 500 ohms. Figure 68.310(c) shows this termination.

(7) For analog registered terminal equipment and protective circuitry for 4-wire network ports, both the off-hook and on-hook requirements apply. The pair not under test shall be terminated in a metallic impedance of 600 ohms. Other conditions are as follows:

(i) For analog registered protective circuitry with loop-start, ground-start, reverse battery, ringdown, or inband signaling; or for voiceband metallic channel applications. Criteria shall be met with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated in an impedance that will result in 600 ohms at each of the transmit and receive pairs of the 4-wire telephone connection in the off-hook state of the registered protective circuit, and the interface should not be terminated in the on-hook state. Figure 68.310(d) shows the interface of the protective circuitry being tested and the required arrangement at the interface to other equipment.

(ii) For analog multiport equipment with loop start, ground start, and reverse battery, ringdown, or inband signaling; or for voiceband metallic channel applications. Criteria shall be satisfied for all network ports when all the ports not under test are terminated as defined below, and when interface connections other than the network ports are terminated in circuits appropriate to the interface. The criteria shall also be satisfied for all values of dc loop current that when the port is connected to the appropriate 4-wire loop simulator circuit. The terminations for both pairs of all network ports not under test shall have a metallic impedance of 600 ohms and a longitudinal impedance of 500 ohms. Figure 68.310(c) shows this termination.

(8) For analog PBX equipment (or similar systems) with class B or class C off-premises interfaces, only off-hook requirements apply. Criteria shall be satisfied for all off-premises station interface ports when these ports are terminated in their appropriate networks for their off-hook state, and when all other interface connections are terminated in circuits appropriate to that interface. The minimum transverse balance coefficients shall also be satisfied for all values of dc loop current that the registered PBX is capable of providing through off-premises station ports when these

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ports are attached to the off-premises line simulator circuit specified in these rules.

(9) For Type Z equipment with loop-start signaling, both off-hook and on-hook requirements apply. Equipment that has on-hook impedance characteristics which that do not conform to the requirements of § 68.312 (e.g., Type Z), shall comply with minimum transverse balance requirements of 40 dB in the voiceband. See § 68.312(h) for conditions upon registration of "Type Z" equipment.

(c) *Digital Equipment.* The minimum transverse balance requirements for registered terminal equipment connected to digital services shall be equalled or exceeded for the range of frequencies applicable for the equipment under test and under all reasonable conditions of the application of earth ground to the equipment. All such terminal equipment shall have a transverse balance in the acceptable region of Figure 68.310(e) for the range of frequencies shown in Table 68.310(b) for the specified digital service in question. The metallic impedance used for the transverse balance measurements for all subrate services shall be 135 ohms and for 1.544 Mbps shall be 100 ohms. The longitudinal termination for 1.544 Mbps and subrate services shall be as defined in Table 68.310(b).

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Table 68.310(b)

Frequency Ranges of Transverse Balance Requirements for Digital Services

| Digital Service | Frequency Range | Longitudinal Termination (ohms) | Metallic Termination (ohms) |
|-----------------|---------------------|---------------------------------|-----------------------------|
| 2.4 | 200 to 2.4 kHz | 500 | 135 |
| 3.2 | 200 to 3.2 kHz | 500 | 135 |
| 4.8 | 200 to 4.8 kHz | 500 | 135 |
| 6.4 | 200 to 6.4 kHz | 500 | 135 |
| 9.6 | 200 to 9.6 kHz | 500 | 135 |
| 12.8* | 200 to 12.8 kHz | 500/90 | 135 |
| 19.2* | 200 to 19.2 kHz | 500/90 | 135 |
| 25.6* | 200 to 25.6 kHz | 500/90 | 135 |
| 38.4* | 200 to 38.4 kHz | 500/90 | 135 |
| 56* | 200 to 56 kHz | 500/90 | 135 |
| 72* | 200 to 72 kHz | 500/90 | 135 |
| 1.544 | 10 kHz to 1 544 MHz | 90 | 100 |

* NOTE: For 200 to 12 kHz the longitudinal termination shall be 500 ohms and above 12 kHz the longitudinal termination shall be 90 ohms.

Appendix C

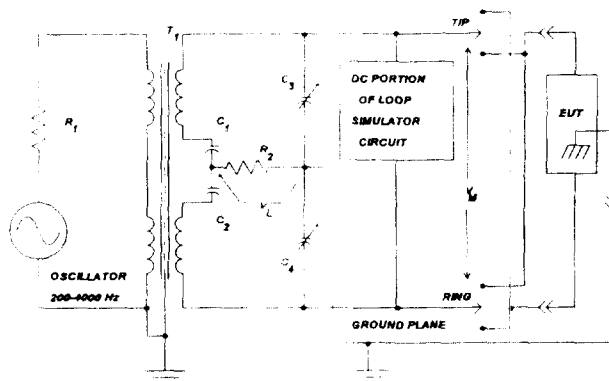


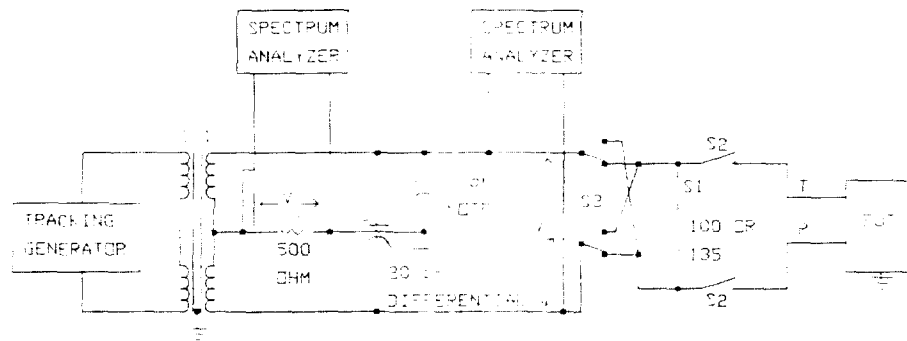
Figure 68.310-1(a)
Illustrative Test Circuit for Transverse Balance (Analog)

- T_1 600 ohms:600 ohms split audio transformer
- C_1, C_2 8 mF, 400 V dc, matched to within 0.1 %
- C_3, C_4 100 to 500 pF adjustable trimmer capacitors
- Osc. Audio oscillator with source resistance R_1 less than or equal to 600 ohms
- R_1 Selected such that $Z_{osc} + R_1 = 600$ ohms
- R_2 500 ohms

NOTES:

1. V_M should not be measured at the same time as V_L
2. Use trimmer capacitors C_3 and C_4 to balance the test circuit to 20 dB greater balance than the equipment standard for all frequencies specified, with a 600 ohm resistor substituted for the equipment under test.
3. Exposed conductive surfaces on the exterior of the equipment under test should be connected to the ground plane for this test.
4. When the Terminal Equipment makes provision for an external connection to ground (G), the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50 % greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

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Notes:

1. The 3 pF capacitor may be placed on either line of the test set, as required, to obtain proper balancing of the bridge.
2. Use an R_{CAL} value of 100 ohms for 1.544 Mbps devices and 135 ohms for subrate devices.
3. The effective output impedance of the tracking generator should match the appropriate test impedance. See Note 2. The spectrum analyzer's input must be differentially balanced to measure V_m .
4. R_2 should be chosen according to Table 68.310(b).

T_1 : 100 ohms:100 ohms C.T. wide band transformer
12.4 to 24.5 pF differential trimmer

$R_2 = Z_1$ from Table 68.310(a)

$R_{CAL} = Z_0$ from Table 68.310(a)

R_1 - Selected so that $R_1 + 50$ ohms = Z_0 from Table 68.310(a)

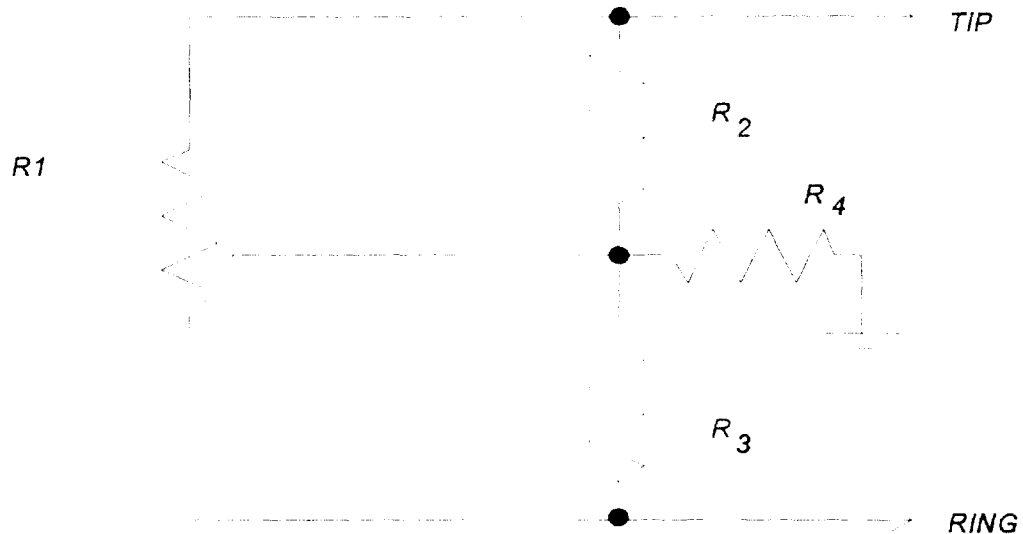
Figure 68.310-1(b)
Illustrative Test Circuit for Transverse Balance (Digital)

Appendix C

Z- Selected so that the reflected impedance at tip and ring is 600 ohms, 135 ohms, or 100 ohms depending on the service type of EUT

Figure 68.310(b)
Required Termination for Connections to Non-Registered Equipment

Appendix C



Where: $R_2 = R_3 = 300$ ohms, $R_4 = 350$ ohms, $R_1 = 300$ k ohms, for analog voiceband

$R_2 = R_3 = 67.5$ ohms, $R_4 = 56.3$ ohms, $R_1 = 100$ kohms, for subrate digital

$R_2 = R_3 = 50$ ohms, $R_4 = 65$ ohms, $R_1 = 100$ k ohms, for 1.544 Mbps

R_1 is used to adjust termination balance. Balance of this termination shall be adjusted to at least 60 dB between 200 and 1000 Hz, and at least 40 dB between 1000 and 4000 Hz, and to at least 35 dB at 1.544 MHz.

Figure 68.310(C)
Off-Hook Termination of Multiport Equipment for Ports Not under Test